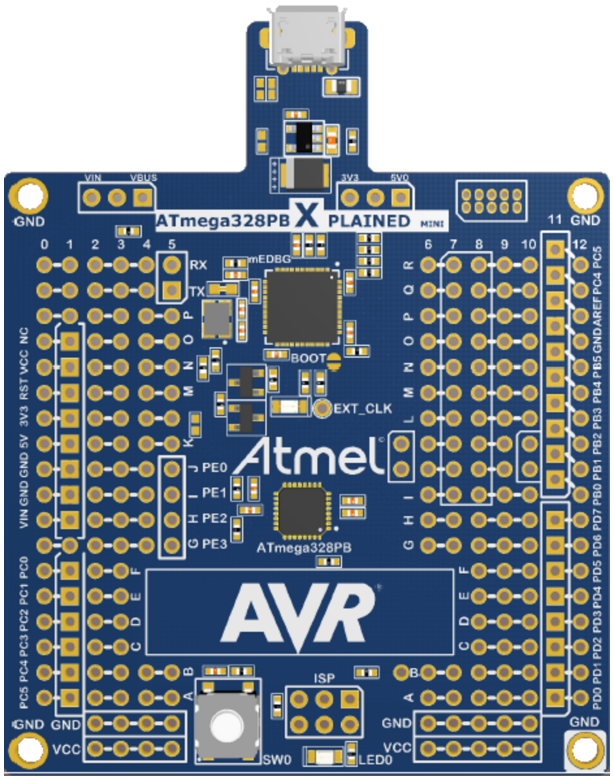
AVR 8-bit Microcontrollers

ATmega328PB Xplained Mini

USER GUIDE

Introduction

This user guide describes how to get started with the Atmel® ATmega328PB Xplained Mini board. The ATmega328PB Xplained Mini evaluation kit is a hardware platform to evaluate the Atmel ATmega328PB microcontroller. The evaluation kit comes with a fully integrated debugger that provides seamless integration with Atmel Studio 6.2 (and later version). The kit provides access to the features of the ATmega328PB enabling easy integration of the device in a custom design.



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1. Getting Started

1.1. Features

The ATmega328PB Xplained Mini evaluation board provides a development platform for the Atmel ATmega328PB.

Key Features

- On-board debugger with full source-level debugging support in Atmel Studio
- Auto-ID for board identification in Atmel Studio
- Access to all signals on target MCU
- One green mEDBG status LED
- One yellow user LED
- One mechanical user push button
- QTouch® user area
- Virtual COM port (CDC)
- External target CLK 16MHz at 5V, 8MHz at 3.3V
- USB powered
- 3V3 regulator
- Arduino shield compatible foot prints
- Target SPI bus header foot print
- Xplained Pro extension headers can easily be strapped in

1.2. Design Documentation and Related Links

The most relevant documents and software for the evaluation board are available here:

Design Documentation - ZIP file containing CAD source, schematics, BOM, assembly drawings, 3D plots, layer plots, etc.

Atmel Studio - Free Atmel IDE for development of C/C++ and assembler code for Atmel microcontrollers.

Xplained - Atmel Xplained prototyping and evaluation platform.

Atmel Spaces - Open Source projects for Xplained Mini.

1.3. Xplained Mini Quick Start

How to connect the ATmega328PB Xplained Mini board embedded debugger to Atmel Studio and how to connect the ATmega328PB UART to a COM port.

1.3.1. Connect to Atmel Studio

How to connect the ATmega328PB Xplained Mini board embedded debugger to Atmel Studio to get started with SW development.

1. Download and install Atmel Studio version 6.2 or later versions.
2. Launch Atmel Studio.
3. Connect the board to the USB port and it will be visible in Atmel Studio.

1.3.2. Connect to the COM Port

How to connect the ATmega328PB UART to a COM port.

All Xplained Mini boards have an embedded debugger (mEBDG) with a number of features, among them a CDC/COM port, which enables the user to connect the ATmega328PB UART to the PC.

1. Connect the Xplained Mini USB to the PC.
2. A COM port named "mEDBG Virtual COM Port" will be available.
3. Start a terminal emulator or other applications using the COM port, typical COM port settings are 9600 baud N81.

1.4. Programming and Debugging

Programming and debugging the ATmega328PB Xplained Mini.

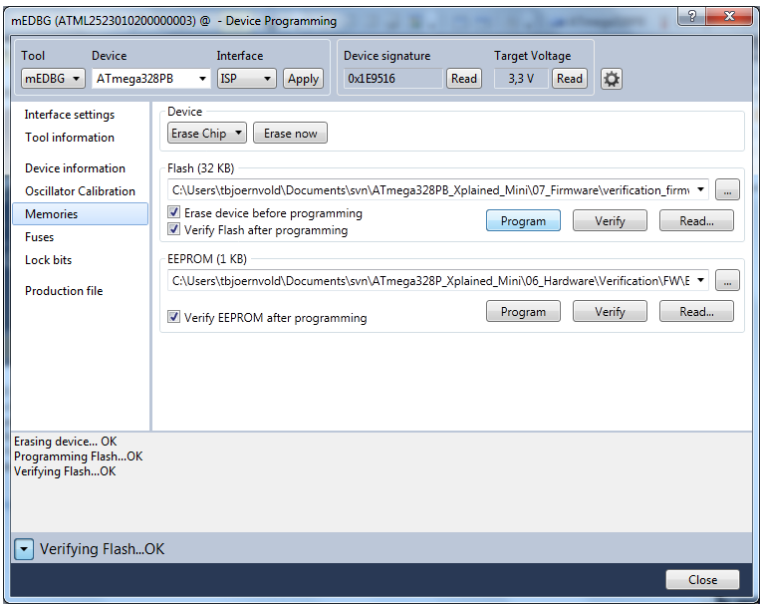
The target micro-controller is the ATmega328PB.

The mEDBG FW is running on the ATmega32U4.

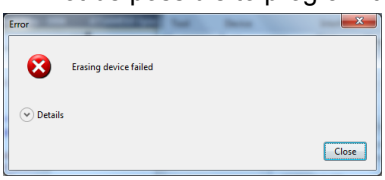
1.4.1. Programming the Target using mEDBG

Using the Embedded Debugger on the ATmega328PB Xplained Mini board to program the ATmega328PB and setting the fuses.

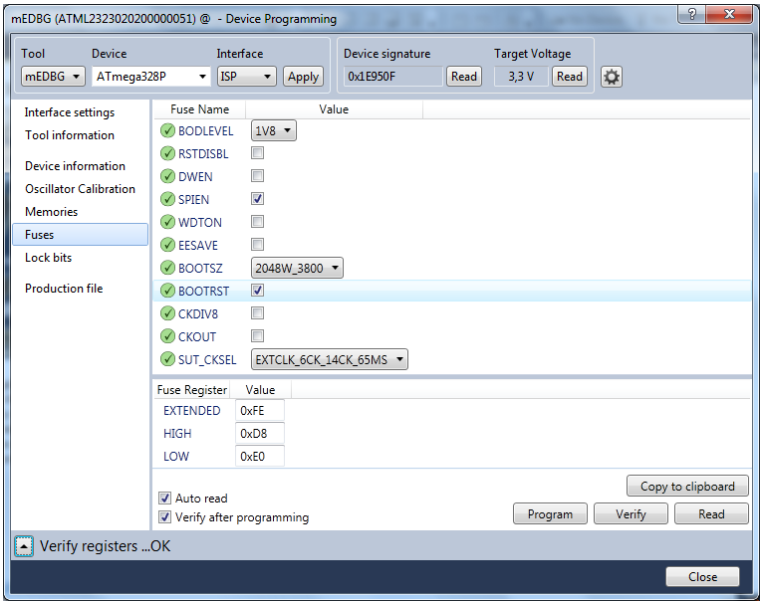
1. Connect the Xplained Mini USB to the PC.
2. Go to Atmel Studio: click the Tools tab, select Device Programming, and select the connected mEDBG as **Tool** with **Device** as ATmega328PB and **Interface** to SPI, click **Apply**.
3. Select "Memories" and locate the source .hex or .elf file and click Program.



4. **NOTE:** If a previous debug session was not closed by selecting "Disable debugWIRE and Close" in the Debug menu, the DWEN fuse will be enabled and the target will still be in debug mode, i.e. it will not be possible to program the target using the SPI.



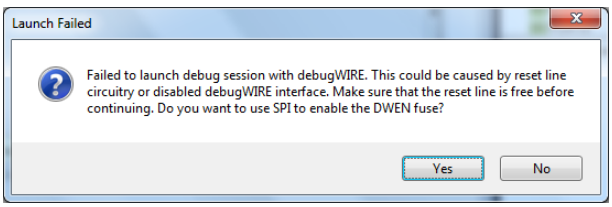
5. If the source file contains fuse settings, select "Production file" and upload the .elf file to program the fuses.
6. Select "Fuses" to program the fuses manually. Set the fuse(s) and click "Program". Recommended fuse settings:



1.4.2. Debugging the Target using mEDBG

Using the Embedded Debugger on the ATmega328PB Xplained Mini board to debug the ATmega328PB via debugWIRE.

1. Start Atmel Studio.
2. Connect the Xplained Mini USB to the PC.
3. Open your project.
4. Click the "Project" tab and select the project "properties", click the "Tools" tab and select mEDBG as debugger and debugWIRE as interface.
5. Click the "Debug" tab and select "Start Debugging and Break".
6. Atmel Studio will display an error message if the DWEN fuse in the ATmega328PB is not enabled, click YES to make Studio set the fuse using the SPI interface.


Launch Failed
Failed to launch debug session with debugWIRE. This could be caused by reset line circuitry or disabled debugWIRE interface. Make sure that the reset line is free before continuing. Do you want to use SPI to enable the DWEN fuse?
Yes
No

7. A debug session is started with a break in main, debugging can start.
8. When exiting debug mode select "Disable debugWIRE and Close" in the Debug tab, this will disable the DWEN fuse.

Important: If not exiting debug mode by selecting "Disable debugWIRE and Close" in the Debug menu, the DWEN fuse will be enabled and the target will still be in debug mode, i.e. it will not be possible to program the target using the SPI.

Important: If any other CPU CLK than the external CLK supplied by the mEDBG is used the debugWIRE is not guaranteed to work.

Important: Applying a signal to J202/RESET (the RESET_SENSE signal) while debugging may result in unexpected behaviour. This signal is NOT available during a debugging session because the RESET line is actively used by the debugWIRE interface

1.4.3. Programming the Target using an External Programmer

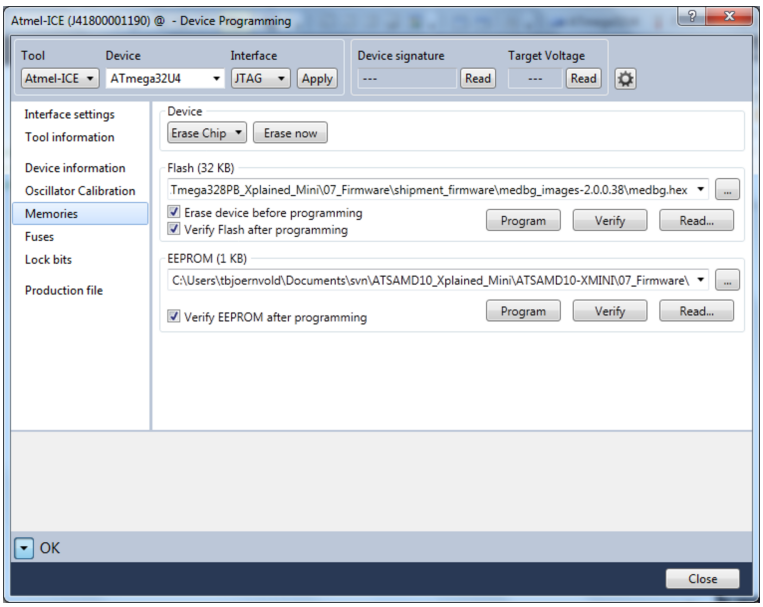
How to program the target ATmega328PB using the AVR® JTAGICE mkII, JTAGICE3, Atmel-ICE, or other Atmel Programmers.

1. Connect the External Programmer USB to the PC.
2. Connect the External Programmer to the ATmega328PB Xplained Mini board SPI connector.
3. Go to Atmel Studio: click the Tools tab, select Device Programming, and select the External Programmer connected as **Tool** with **Device** as ATmega328PB and **Interface** to SPI, click **Apply**.
4. Select "Memories" and locate the source .hex or .elf file and click Program.

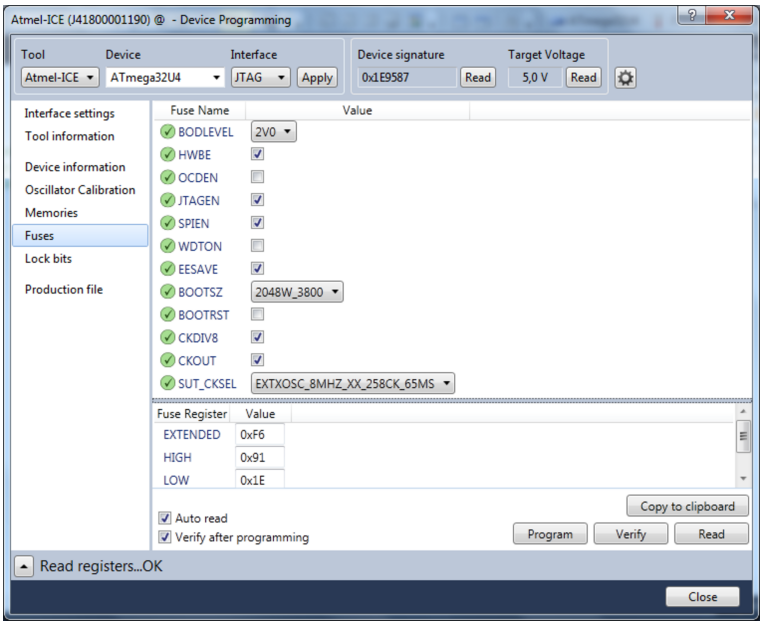
1.4.4. Programming the ATmega32U4 using an External Programmer

How to program the ATmega32U4 using the AVR® JTAGICE mkII, JTAGICE3, Atmel-ICE, or other Atmel Programmers.

1. Connect the External Programmer USB to the PC.
2. Connect the External Programmer to the ATmega328PB Xplained Mini board JTAG connector.
3. Go to Atmel Studio: click the Tools tab, select Device Programming, and select the connected mEDBG as **Tool** with **Device** as ATmega32U4 and **Interface** to JTAG, click **Apply**.
4. Select "Memories" and locate the source .hex or .elf file and click Program.



5. Select "Fuses" to program the fuses manually. Set the fuse(s) and click "Program". Recommended fuse settings:



1.4.5. Programming the ATmega32U4 using a Bootloader

This section describes how to use the bootloader to program the ATmega32U4.

1. Install the Bootloader interface on the PC, download the installer from FLIP.
2. Start the Bootloader PC GUI "FLIP".
3. Short strap J102.
4. Connect the ATmega328PB Xplained Mini board USB connector to the PC.
5. Select Device = ATmega32U4 (Device - Select).
6. Select USB communication (Ctrl+U).
7. Select memory area to program (use the toggle memory button bellow the Atmel logo).
8. Select Load Hex file (Ctrl+L).

9. Select Programming Options.
10. Click "Run", observe status in status field.

1.5. Board Assembly

The Xplained Mini board can easily be assembled into a product prototype for software development and hardware verification.

1.5.1. Custom Assembly

All signals of the ATmega328PB are available in the Xplained Mini board connector grid, enabling easy connection of external sensors and output devices in order to prototype the customer specific application.

1.5.2. Standalone Node

The ATmega328PB Xplained Mini board can be used as a standalone node with an external power source, e.g. the 4xAAA or 2xAAA battery pack available from Atmel.

1.5.3. Connecting an Arduino Shield

Arduino® shields can be mounted in the marked positions (J200, J201, J202, and J203) .

1.6. mEDBG Command Line Interface

The mEDBG has a command line interface enabling configuration of the mEDBG.

1.6.1. mEDBG Low Power Modes

There are two modes enabling the Xplained Mini to save power when connected to an external power source other than an USB connection.

Sleep Mode where the mEDBG is disabled. When enabled the ATmega32U4 will enter sleep mode if not enumerated within about 5sec. In this mode the external clock is not available to the target MCU.

1MHz Mode where the mEDBG/ATmega32U4 is set to run at 1MHz, saving power while maintaining the USB connection for the COM port. The external clock will be 1MHz.

Table 1-1 Available Commands

Mode	Command	External CLK	COM port	mEDBG program	mEDBG debug
Sleep	0xFB (bit2=0)	disabled	disabled	disabled	disabled
1MHz	0xFD (bit1=0)	1MHz	enabled	useless	useless
Factory settings	0xFF	16MHz (@5V) 8MHz (@3V3)	enabled	enabled	enabled

1.6.2. mEDBG Fuse Filter

The mEDBG does not initially allow users to program the CLK related fuses in the target. This is done to avoid problems with the debugger when the target and mEDBG is not in CLK sync. This filter can be disabled by issuing the command 0xFE (bit0 = 0) enabling configuration of all ATmega328PB fuses.

1.6.3. How to Issue Commands

The command line interface is supported by mEDBG version 1.6 or later.

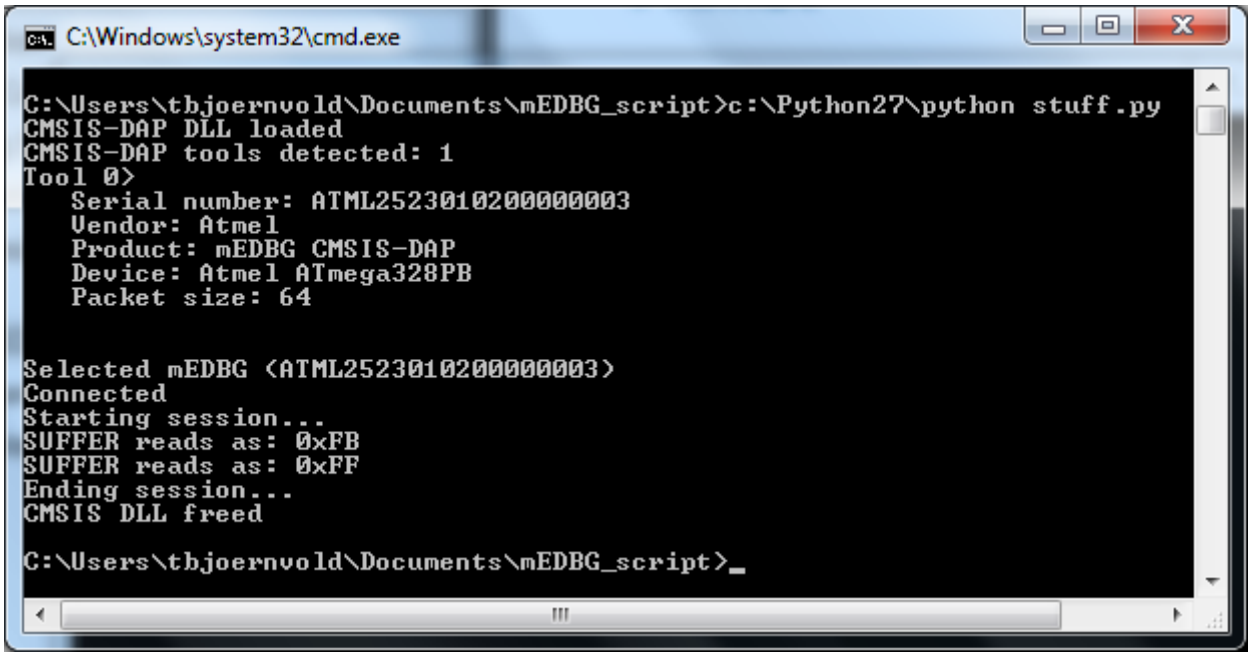
The mEDBG command line interface can be accessed with the Python script found on Atmel Spaces Releases (mEDBG_script.zip).

If you have Studio 7.0 (and later versions), the mEDBG included supports the command line interface, if not, the mEDBG can be downloaded from Atmel Spaces Releases (medbg_fw.zip).

Basic Python is required to run the script, Python can be downloaded from Python.

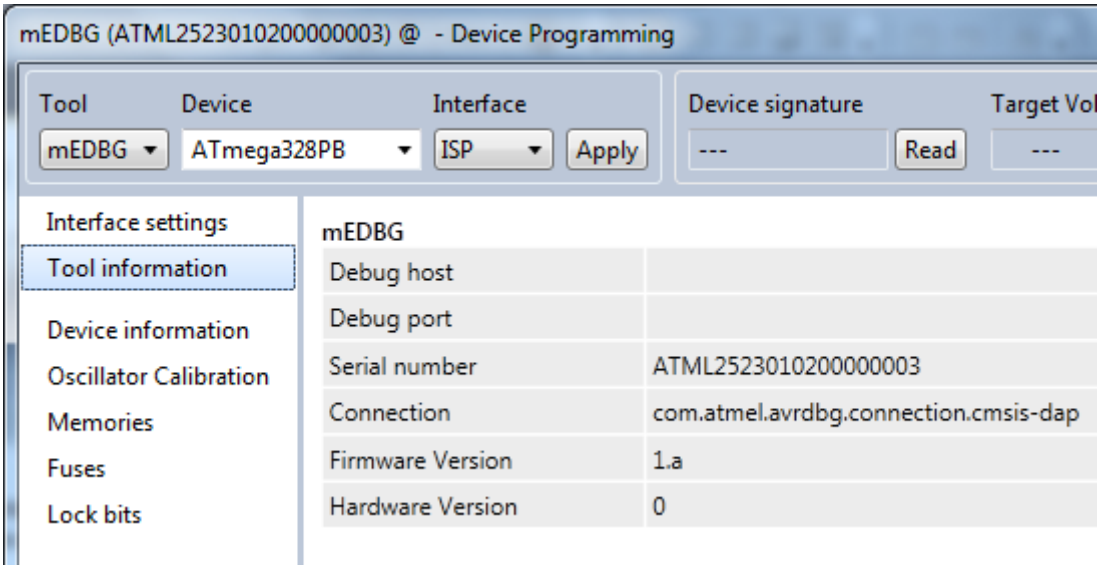
How to issue commands

1. Install Python.
2. Download the file "mEDBG_script.zip" from Atmel Spaces Releases.
3. Unzip the file "mEDBG_script.zip".
4. Edit "stuff.py" to issue the selected command "c.set_suffer(0xXX)".
5. Open a command window in the directory where "stuff.py" is located. (Browse to the, folder right-click on folder with shift pressed and select “Open command window here”.)
6. Connect the Xplained Mini.
7. Run "stuff.py" (c:\Python27\python stuff.py).
8. The script will print the selected tool and display SUFFER setting.
9. Recycle power (disconnect/connect the board) for the change to take effect.
10. Edit "stuff.py" to issue the command c.set_suffer(0xFF) to reset to factory setting.



How to upgrade the Xplained Mini mEDBG

1. Start Atmel Studio.
2. Connect the Xplained Mini to the computer.
3. In Atmel Studio, select Tools – Device programming (Ctrl – Shift – P)
4. In the Device Programming window, select Tool to mEDBG and click Apply. If there is a new mEDBG version available, the Atmel Studio will ask if you want to upgrade.
5. To verify mEDBG version, click "Tool Information" when mEDBG is selected as Tool.


mEDBG (ATML2523010200000003) @ - Device Programming
Tool
Device
Interface
Device signature
Target Vol
mEDBG
ATmega328PB
ISP
Apply

Read

Interface settings
Tool information
Device information
Oscillator Calibration
Memories
Fuses
Lock bits
mEDBG
Debug host
Debug port
Serial number
ATML2523010200000003
Connection
com.atmel.avrdbg.connection.cmsis-dap
Firmware Version
1.a
Hardware Version
0

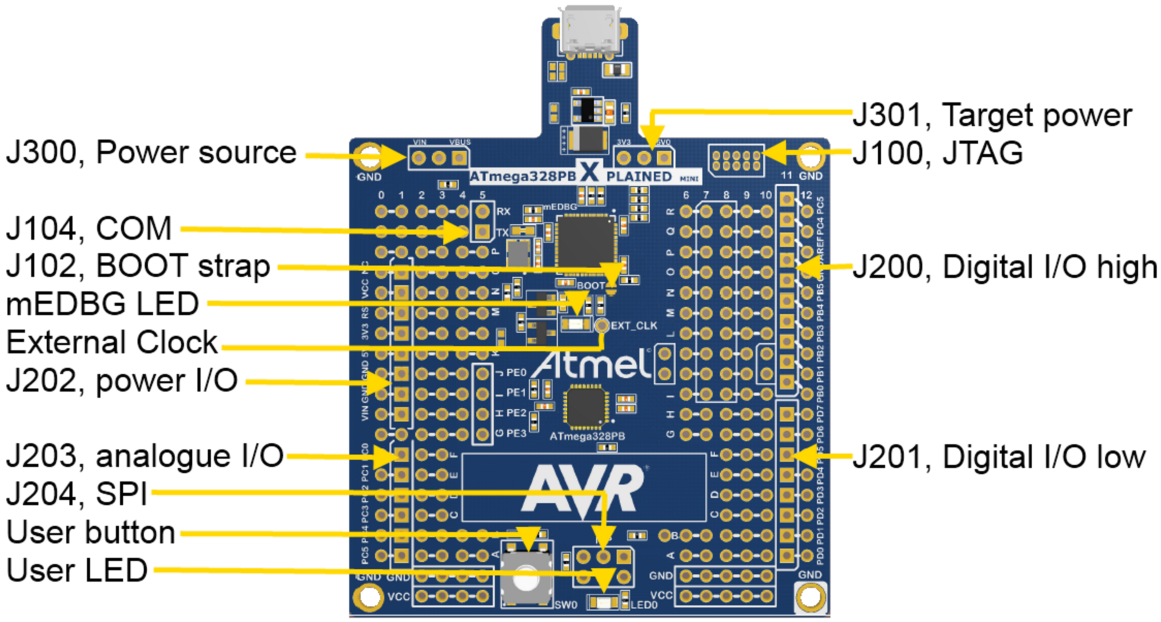
2. Hardware User Guide

Enter a short description of your concept here (optional).

This is the start of your concept.

2.1. Board Overview

The ATmega328PB Xplained Mini headers overview.



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2.2. Target Headers and Connectors

The ATmega328PB related headers.

2.2.1. Target Digital I/O

The J200 and J201 headers provide access to the ATmega328PB digital I/O pins.

Table 2-1 J200 Digital I/O High Byte Header

J200 pin	ATmega328PB pin	Function
1	PB0	
2	PB1	
3	PB2	SS, SPI Bus Master Slave select
4	PB3	MOSI, SPI Bus Master Output/Slave Input
5	PB4	MISO, SPI Bus Master Input/Slave Output
6	PB5	SCK, SPI Bus Master clock Input
7	GND	

J200 pin	ATmega328PB pin	Function
8	AREF	
9	PC4	SDA, 2-wire Serial Bus Data Input/Output Line. Shared with ADC4
10	PC5	SCL, 2-wire Serial Bus Clock Line. Shared with ADC5

Table 2-2 J201 Digital I/O High Low Header

J201 pin	ATmega328PB pin	Function
1	PD0	TXD (ATmega328PB USART Output Pin)
2	PD1	RXD (ATmega328PB USART Input Pin)
3	PD2	
4	PD3	
5	PD4	
6	PD5	
7	PD6	
8	PD7	

2.2.2. Board Power Header

The J202 header enables connection to the ATmega328PB Xplained Mini power system.

Table 2-3 J202 Power Header

J202 pin	Signal	Description
1	NC	
2	VCC_TARGET	The power source selected for the target. (Select by J301)
3	RESET_SENSE	This is a RESET signal monitored by the mEDBG, if pulled low the target RESET line will be pulled low by the mEDBG. The ATmega32U4 internal pull-up is enabled. This signal is not available during debugging.
4	VCC_P3V3	The 3.3V regulator output
5	VCC_P5V0	The selected power source. (VIN or VBUS selected by J300)
6	GND	
7	GND	
8	VCC_VIN	The external power source connection.

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2.2.3. Target Analogue I/O

The ATmega328PB ADC input pins are available in the J203 header.

AREF is available in J200 pin 8.

Table 2-4 J203 Analogue Header

J203 pin	ATmega328PB pin	Function
1	PC0	ADC Input Channel 0
2	PC1	ADC Input Channel 1
3	PC2	ADC Input Channel 2
4	PC3	ADC Input Channel 3
5	PC4	ADC Input Channel 4
6	PC5	ADC Input Channel 5

2.2.4. Target Programming

The J204 header enable direct connection to the SPI bus with an external programmer for programming of the ATmega328PB.

Table 2-5 SPI Header

J204 pin	ATmega328PB pin	Function
1	PB4	MISO
2		VCC target
3	PB5	SCK
4	PB3	MOSI
5	PC6	RESET
6		GND

2.2.5. Target Additional I/O

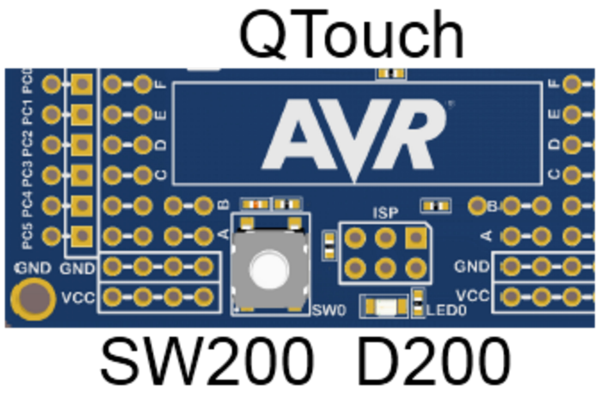
Signals not available in any of the headers or connectors, are available in column 5 of the grid.

Table 2-6 Additional I/O

ATmega328PB pin	Grid position
PE0	J5
PE1	I5
PE2	H5
PE3	G5

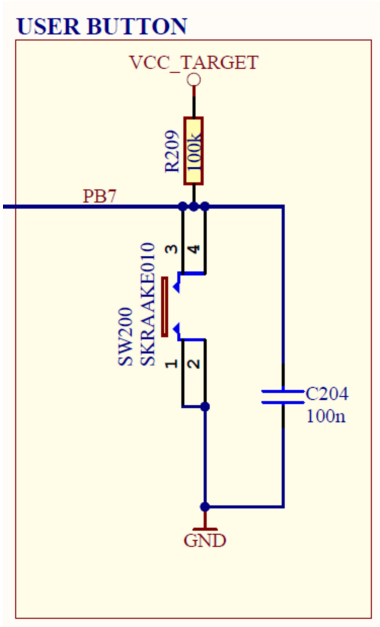
2.3. Target GUI

The ATmega328PB Xplained Mini has One LED, one push button, and a QTouch area.



2.3.1. Push Button

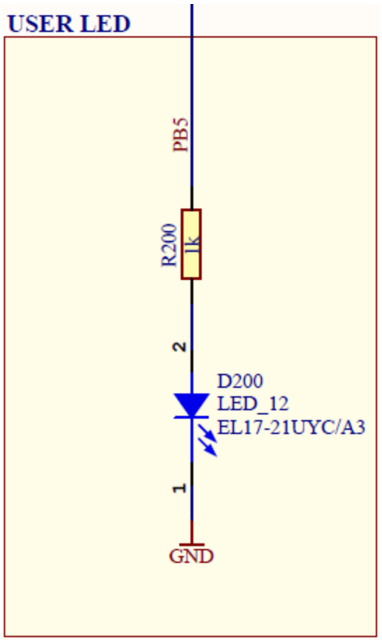
A general purpose push button, SW200, is connected to PB7.



2.3.2. User LED

There is one yellow LED, D200, available for use by the application SW.

The LED is connected to ATmega328PB pin 17 - PB5 and to the SPI bus SCK signal for, SCK is in 3-state when not used by the mEDBG.



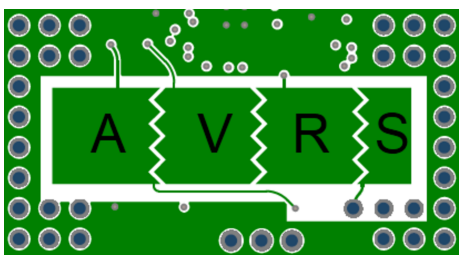
2.3.3. QTouch buttons

Up to 4 QTouch buttons are available on the ATmega328PB Xplained Mini board. The QTouch area can be configured as buttons or as a limited slider. For a typical button or slider reference design use the QT1 Xplained Pro extension.

Tip: There is a range of QTouch reference designs demonstrated with the QT Xplained Pro extensions located at
Xplained - Atmel Xplained prototyping and evaluation platform.

Table 2-7 QTouch Buttons Wiring

Button	ATmega328PB	PTC	
A	PE2 via 100k.	Y6	
V	PE3 via 100k.	Y7	
R	PC3 via 100k.	Y3	
S	Connected via 0Ω to A enabling slider configuration.		



In the default HW configuration the QTouch area can be configured in SW as 3 buttons or as a limited slider.

To get 4 buttons the S touch area can be connected to e.g. PC2 by removing the 0Ω resistor R214 and adding a wire or a 100k resistor from PC2 (D1) to the test point in B5.5.

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2.4. On-board Power Supply

The ATmega328PB Xplained Mini board has an on-board 3.3V regulator (150mA) which can be used to power the ATmega328PB.

The J300 and J301 headers configure the ATmega328PB power supply and the board power source.

The default configuration is set by R300 and R301 0Ω resistors which can be easily removed to change the default configuration.

Table 2-8 Board Power Options

Mode	J301 connection, target	J300 connection, board	Function
5V (Default)	pin2 connected to pin1	pin2 connected to pin1	Board and target powered by VBUS
3.3V USB	pin2 connected to pin3, remove R301	pin2 connected to pin1	Target powered by 3.3V and USB interface powered by VBUS
VIN	pin2 connected to pin1	pin2 connected to pin3, remove R300	Board and target powered by VIN, J202.8. 1.8V < VIN < 5.5V
3.3V VIN	pin2 connected to pin3, remove R301	pin2 connected to pin3, remove R300	Target powered by 3.3V. VIN as regulator input. 4V < VIN < 16V

Tip: Use the BOD LEVEL fuse to avoid the following challenges:
For the CPU to successfully decode and execute instructions, the supplied voltage must always stay above the minimum voltage level set by the chosen operating frequency.

When supplied voltage drops below this level, the CPU may start to execute some instructions incorrectly. The result is unexpected activity on the internal data and control lines.

This activity may cause CPU Registers, I/O Registers and Data Memories to get corrupted.

To avoid these problems, the CPU should be prevented from executing code during periods of insufficient supply voltage.

2.5. mEDBG

The ATmega328PB Xplained Mini board has an embedded debugger/programmer enabling debugging and programming of the ATmega328PB without any additional external equipment.

2.5.1. mEDBG Status LED

The mEDBG has a green status LED connected to ATmega32U4 PC6 to signal the embedded debugger state.

Table 2-9 mEDBG Green Status LED Function

mEDBG state	LED	Function
Enumeration	ON	During the initial USB connection process the LED is on until enumerated or if not enumerated it is turned off within about 5 seconds
Programming	ON	The LED is on during programming
Debugging	ON	The LED is on when the debugger is running

2.5.2. mEDBG External Clock

The mEDBG (ATmega32U4) clock out signal (PC7) is connected to the ATmega328PB external clock input signal and can be used as the system clock source. The External Clock frequency is 16MHz when the target is running at 5V and 8MHz when running at 3V3.

Tip: The External Clock can be set to 1MHz to save power using the mEDBG command line interface.

Tip: There is a test point marked EXT.CLK enabling easy measuring and/or connection to the CLK signal.

2.5.3. mEDBG COM Port Connection

The mEDBG provide a CDC COM port connection when connected to a USB host device.

The mEDBG (ATmega32U4) USART is used for communication with the CDC COM port. The USART TX/RX signals are available on the J104 header and are also connected to the ATmega328PB via 0Ω resistors enabling easy disconnect from the ATmega328PB if needed.

Table 2-10 J104 USART Header

J104 pin	ATmega32U4	ATmega328PB	Function
1 - USART TxD	PD3	PD1	TxD out from ATmega32U4
2 - USART RxD	PD2	PD0	RxD in to ATmega32U4

2.5.4. mEDBG JTAG Interface

The mEDBG (ATmega32U4) JTAG interface is available for programming and debugging of the ATmega32U4.

Table 2-11 J100 JTAG Header

J100 pin	Signal name	Description
1	TCK	
2	GND	
3	TDO	
4	VCC_BOARD	ATmega32U4 V_{CC}

J100 pin	Signal name	Description
5	TMS	
6	RESET	Connected to ATmega32U4 only
7	NC	
8	NC	
9	TDI	
10	GND	

2.5.5. mEDBG USB Interface

J101 is a Micro-B USB connector connected to the embedded debugger (ATmega32U4).

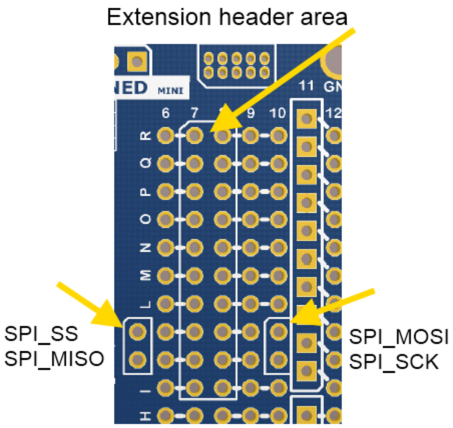
Table 2-12 J101 USB Header

J101 pin	Signal name
1	VBUS
2	D-
3	D+
4	NC
5	GND

The VBUS has a resettable PTC fuse (F100), with a hold current of 0.5A and a trip current of 1.0A to protect the USB host device.

2.6. Extension Header Area

The marked area on the grid I7 to R8 can be used for strapping in an Xplained Pro extension header or a 10-pin Xplained/RZ600 header.



The SPI bus signals are made available close to the header at row J and K, enabling easy connection to header pin 15 to 18.

Using Pin 11 to 20 enables connection of the 10-pin connector used on the RZ600 wireless modules and the 10-pin Xplained sensor modules.

The general bus connections for an Xplained PRO Extension board is indicated in the table below, detailed wiring can be found in the selected extension board documentation.

Table 2-13 Extension Header Typical Signals

Pin	Signal name	Signal description
1	ID	Communication line to the ID chip on the Xplained extension board
2	GND	Ground
3	ADC(+)	Analog to digital converter, alternatively positive part of differential ADC
4	ADC(-)	Analog to digital converter, alternatively negative part of differential ADC
5	GPIO1	General purpose I/O
6	GPIO2	General purpose I/O
7	PWM(+)	Pulse width modulation, alternatively positive part of differential PWM
8	PWM(-)	Pulse width modulation, alternatively negative part of differential PWM
9	IRQ/GPIO	Interrupt request line and/or general purpose I/O
10	SPI_SS_B/ GPIO	Slave B select for SPI and/or general purpose I/O
11	I2C_SDA	Data line for I^2C interface
12	I2C_SCL	Clock line for I^2C interface
13	UART_RX	Receiver line of ATmega328PB USART
14	UART_TX	Transmitter line of ATmega328PB USART
15	SPI_SS_A	Slave A select for SPI
16	SPI_MOSI	Master out slave in line of serial peripheral interface
17	SPI_MISO	Master in slave out line of serial peripheral interface
18	SPI_SCK	Clock for serial peripheral interface
19	GND	Ground
20	VCC	Power for extension board

2.7. Factory Programmed

The ATmega328PB is preprogrammed with a demo program, ReMorse.

Source code is available in Atmel Spaces.

When the CDC COM port is connected to a terminal window (9600 N81), the text you write will be transmitted via the LED in Morse code. Any Morse code transmitted by using the switch will be displayed as text in the terminal window.

The ATmega32U4 is preprogrammed with the mEDBG.

2.8. Document Revision History

Document revision	Date	Comment
42469A	07/2015	Initial document release

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